Investigation of the Frequency and Force of Chest Vibration Performed by Physiotherapists

S.K. Li, Y.R. Silva

ABSTRACT

Purpose: To investigate the frequency and force of chest vibration as applied by 18 physiotherapists working in a teaching hospital.
Method: Chest vibration was applied to a healthy adult male lying supine on a plinth with seven mounted sensors measuring frequency and force, during three test conditions: (1) directly on the chest, (2) on the chest through a layer of sheet, and (3) on the chest through a layer of towelling. The influence of gender and current practice area (physiotherapists working in cardiopulmonary areas [cardiopulmonary physiotherapists] and physiotherapists who presently did not work in the cardiopulmonary area, but had treated cardiopulmonary patients within the last year [general practice physiotherapists]) on the frequency and force of chest vibrations was examined.
Results: Physiotherapists demonstrated a mean frequency of 5.7, 5.3, and 5 Hz and a mean maximum force of 272.78, 273.47, and 271.13 N for conditions 1, 2, and 3 respectively. There were no significant differences in the frequency or forces generated by vibration between cardiopulmonary and general practice physiotherapists, between genders, or among the three test conditions.
Conclusions: Vibration frequency was lower and force higher than previously recorded. Force may vary depending on the patient. The addition of a sheet or towel did not affect the force or frequency of vibration compared to vibration performed directly on the chest.

Key Words: chest shaking, chest vibration, force, frequency

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RÉSUMÉ

Objet : Enquêter sur la fréquence et sur la force de la vibration thoracique appliquée par 18 physiothérapeutes qui travaillent dans un hôpital d'enseignement.
Méthodologie : La vibration thoracique a été appliquée à un homme adulte et en santé en position allongée sur un socle avec sept capteurs montés pour mesurer la fréquence et la force, durant trois conditions d'essai : 1) directement sur le thorax, 2) sur le thorax à travers l'épaisseur d'un drap et 3) sur le thorax à travers l'épaisseur d'une serviette. On a examiné l'influence du sexe et du champ d'exercice actuel (les physiothérapeutes qui travaillent dans les domaines des maladies cardio-pulmonaires [physiothérapeutes cardio-pulmonaires] et les physiothérapeutes qui ne travaillaient pas dans le domaine cardio-pulmonaire, mais avaient traité des patients cardio-pulmonaires au cours de la dernière année [physiothérapeutes de pratique générale]) sur la fréquence et la force de la vibration pectorale.
Résultats : Les physiothérapeutes ont démontré une fréquence moyenne de 5,7, 5,3 et 5 Hz et une force maximale moyenne de 272,78, 273,47 et 271,13 N pour les conditions 1, 2 et 3, respectivement. Il n'y a pas eu de différences importantes dans la fréquence ou les forces générées par la vibration entre les physiothérapeutes cardio-pulmonaires et de pratique générale, selon le sexe ni entre les conditions des trois essais.
Conclusion : La fréquence de la vibration était plus faible et la force plus élevée que celles inscrites précédemment. La force peut varier selon le patient. L'ajout d'un drap ou d'une serviette n'a pas joué sur la force ni sur la fréquence de la vibration en comparaison de la vibration faite directement sur le thorax.

Mots clés : ébranlement thoracique, force, fréquence, vibration thoracique

BACKGROUND

Chest vibration and chest shaking are manual techniques used by physiotherapists to assist in airway clearance. The oscillatory action can be a fine movement or a coarse movement, defined as chest vibration and chest shaking respectively.[1] Chest vibration involves placing the hands on the patient's chest wall and applying an oscillatory action in the direction of the normal movement of the ribs during expiration, using the physiotherapist's body weight.[1] This is thought to lead to production of phasic energy waves, which are transmitted to the airways during expiration and may augment expiratory flow.[2]

The study was approved by the Human Research and Ethics Committee of Concord Repatriation General Hospital, Sydney, Australia. Informed consent was obtained from all participants in the study.

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Chest vibratory force[3] and frequency (3–17 Hz)[4] applied to the chest wall have been shown to increase expiratory flow rates in dogs. A study investigating vibration on a human model reported a mean frequency of 5.5 Hz and a mean peak force of 137.1 N.[5] That study also demonstrated a mean expiratory flow rate of 0.97 (l/s), which was 20% less than a cough or huff but greater than relaxed expiration from total lung capacity or tidal breathing.[5] Physiotherapists in that study had a mean of 10.5 years' clinical experience, including an average of 8.6 years working in a cardiopulmonary area. However, the majority of physiotherapists working at the teaching hospital in Sydney in which the current study was conducted have less experience, with a mean of 2.9 years for cardiopulmonary physiotherapists and a mean of 1.2 years for general practice physiotherapists. It is unclear whether physiotherapists with less experience can replicate the above results when applying chest vibration.

Chest vibration is usually carried out over normal clothing or towelling, if used in combination with percussion. Currently no study has evaluated the force and frequency of chest vibration when performed directly on the body or over a layer of sheet or towelling.[5–7]

The primary aim of this study was to investigate the forces and frequencies of chest vibration produced on a human chest by physiotherapists working in a teaching hospital. The physiotherapists at this hospital had far less experience than those in the previous study.[5] The second aim of the study was to establish whether applying chest vibration directly on the body as opposed to over a layer of sheet or towelling altered the force and frequency of vibration. The final aim was to determine whether there were any differences in the force and frequency of chest vibration due to gender or between physiotherapists working in cardiopulmonary areas (cardiopulmonary physiotherapists) and those who did not work currently in the cardiopulmonary area but had treated cardiopulmonary patients within the last year (general practice physiotherapists).

METHOD

Participants

All physiotherapists currently employed at Concord Repatriation General Hospital in Sydney, Australia, a teaching hospital for the University of Sydney, were invited to participate for the study. The study was approved by the Human Research and Ethics Committee of Concord Hospital. Informed consent was obtained from all physiotherapists who participated in the study. Five male and 13 female physiotherapists (5 cardiopulmonary and 13 general practice physiotherapists) volunteered for the study.

Instrument Set-Up

The magnitude and direction of forces applied were measured by a plinth modified with seven load cells between the frame and the top of the plinth. Force data were used to determine the frequency of vibration. This instrument was developed for another study that measured the three-dimensional forces applied during mobilization of the lumbar spine.[8] The instrument set-up for this study was exactly the same as for the previous study.

To measure forces applied during chest vibration, four-, two-, and one-load cells were positioned in vertical, medial-to-lateral, and caudad-to-cephalad directions.[8] Forces were measured in the following directions: vertical (downward on to the plinth from the physiotherapist's hands on the healthy volunteer), medial (transverse force toward the physiotherapist's hands on the volunteer), lateral (transverse force away from the physiotherapist's hands on the volunteer), cephalad (transverse force directed away from the physiotherapist's hands toward the head of the volunteer), and caudad (transverse force directed away from the physiotherapist's hands toward the legs of the volunteer). The combined result of these forces on the airway may contribute toward improved expiratory flow. In this study, only the individual forces applied during chest vibration were measured.

The load cells were connected to an amplifier mounted on the plinth frame that sent signals to a desktop computer via a data-acquisition package developed internally. This software allowed the operator to calibrate the force and frequency signals prior to data collection. While the raw data sets were collected, the software numerically displayed the force characteristics, which were then imported into Microsoft Excel (Microsoft Corp., Redmond, WA) for analysis.[8] This equipment has been demonstrated to be highly accurate, with an average error of less than 1% when applying forces to a human body lying on the plinth and less than 2% when measuring forces on an empty plinth.[8]

Experimental Set-Up

The volunteer ''patient'' was an adult male, with a body mass index (BMI) of 33 kg/m^2, who had normal lung function and no history of smoking. He was positioned on his right side, as close as possible to the edge of the plinth. The plinth was placed parallel to the ground.

Procedure

The volunteer was instructed to do three deep inspiratory breaths, each followed by relaxed expiration. Three to four deep breaths are usually appropriate, as more may cause the patient to tire or hyperventilate.[1] Vibration was applied during the expiratory phase of each deep breath.[1] The force and frequency of vibration were recorded over a 10-second period, approximating the time required to take three deep breaths.

The task involved the physiotherapists' vibrating the lower left lateral lung zone of the volunteer ''patient.'' The height of the plinth was adjusted by each physiotherapist. The physiotherapists were instructed to perform chest vibration only during the expiration phase, without leaning on the plinth, but were not shown how to apply vibration. To establish rate and rhythm of vibration, they were each allowed a trial session with the patient on the plinth for two 10-second periods. After the trial session, each therapist had a two-minute rest prior to performing vibration in each of the three test conditions.

Vibration was assessed on the volunteer's skin, with one layer of sheet over the body, and with one layer of towelling over the body. In order to ensure randomization, the three conditions were numbered, and the numbers put in an envelope; each physiotherapist drew the numbers out of an envelope and performed the procedure in the three conditions in that order. A rest period of two minutes was allowed between conditions. Vibration was performed once for each of the three conditions. The frequency and force of vibration for all three conditions, each over a 10-second duration, were determined for each physiotherapist.

The consistency of the experimental set-up was tested after 10 days by repeating the test being with three physiotherapists randomly selected from among those who participated in the study.

Statistical Analysis

Data were analysed using the Statistical Package for the Social Sciences, version 7 package (SPSS Inc., Chicago, IL). To investigate the differences between group factors (gender at two levels: male and female; and practice area at two levels: cardiopulmonary and general practice), an independent *t*-test was used. Repeated-measures ANOVA was applied to analyse the within-group factor (condition at three levels: skin, sheet, and towel). A critical alpha value of 0.05 was used to determine statistical significance.

RESULTS

Eighteen physiotherapists (5 men and 13 women) volunteered for the study. There were 2 male and 3 female cardiopulmonary physiotherapists as well as 3 male and 10 female general practice physiotherapists. The cardiopulmonary physiotherapists had a mean of 2.9 years' clinical experience (minimum, maximum: 6 months, 5 years) with a mean of 1.2 years' experience working in the cardiopulmonary area (minimum, maximum: 6 months, 2 years). The general practice physiotherapists had a mean of 1.9 years (minimum, maximum: 6 months, 5 years) of general clinical experience.

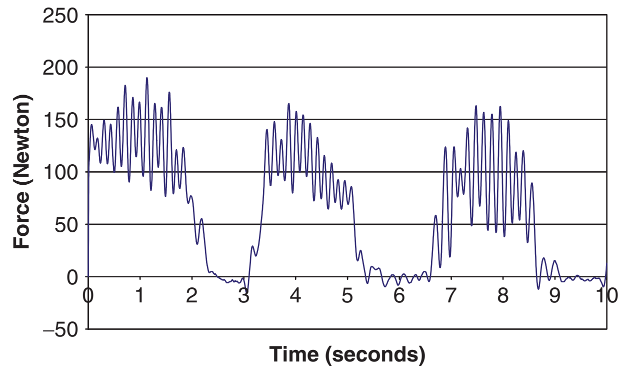

Figure 1 Force–time curve representing the vibration technique over a 10-second duration

Chest vibration was defined as a sinusoidal force waveform (see Figure 1). The volunteer's inspiration and expiration time for the waveform were 1 and 2 seconds respectively. A trace during a single application of chest vibration showed that the force was zero during the inspiratory phase (Figure 1). During the expiratory phase, the physiotherapists applied vibration that had a compressive force and superimposed oscillations. The applied force was increased and decreased to produce the oscillations, with the physiotherapist's hands never losing contact with the volunteer's chest wall during expiration. As the force was reduced on the chest, recoil of tissues induced an upward deceleration force that resulted in a lesser value for minimal force. However, this minimal force did not reach zero Newton force. During the inspiratory phase, all but three physiotherapists kept their hands on the volunteer's chest. This pattern did not change across the three experimental conditions.

All 18 physiotherapists were asked to perform chest vibration. The waveform pattern of three physiotherapists consistently showed chest shaking in all three conditions. A chest-shaking waveform pattern was noted for two physiotherapists when performing vibration directly on the body and for another two physiotherapists when applying vibration through a layer of towelling.

Chest shaking showed a similar sinusoidal force waveform to chest vibration (see Figure 2). Because a higher force is applied during chest shaking, when the force was reduced the recoil of tissues induced an upward deceleration force such that the minimal force was zero or negative Newton force. As a result, the oscillations for chest shaking were of larger amplitude than those of chest vibration. As it was not clear why some physiotherapists performed chest shaking rather than chest vibration, we decided to evaluate the frequency and force of chest shaking, even though this had not been one of the aims of the study. In addition, the few physiotherapists who performed chest shaking tended to compress the chest wall during the inspiratory phase, prior to performing the technique (Figure 2). This resulted in an inspiratory force higher than zero.

Frequency

Frequency is counted by the cycles per expiration and then converted to cycles per second. Results of the three conditions are listed in Table 1. There was no significant difference among the three conditions for vibration ($F_{2,34} = 2.53$, $p = 0.09$).

Female physiotherapists tended to have a higher frequency when applying chest vibration directly over the body ($t_{16} = -2.41$, $p = 0.030$) but not when applying chest vibration through one layer of sheet or through a towel ($t_{16} = -1.43$, $p = 0.17$; $t_{16} = -1.47$, $p = 0.15$, respectively).

Again, there was no significant difference in the frequency of chest vibration technique between the cardiopulmonary physiotherapists and the general practice physiotherapists when applying vibration directly over the body, through a layer of sheet, or through a towel ($t_{16} = 0.61$, $p = 0.55$; $t_{16} = 0.82$, $p = 0.42$; and $t_{16} = 0.98$, $p = 0.34$, respectively).

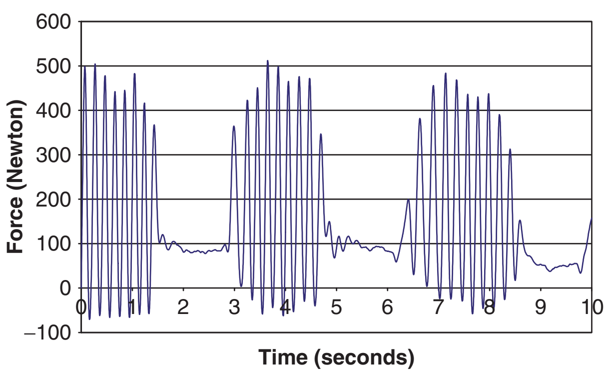

Figure 2 Vertical force–time curve representing the shaking technique over a 10-second duration

Force

Three-dimensional forces were recorded. The data represent the average of three deep breaths during 10 seconds of recording (see Table 2).

There was no significant difference in the applied peak vertical force of chest vibration among the three conditions for the repeated-measures ANOVA ($F_{2,34} = 0.60$, $p = 0.55$). Again, no significant difference was found in the peak vertical forces produced between cardiopulmonary physiotherapists and general practice physiotherapists when applying chest vibration directly on the body ($t_{16} = -0.58$, $p = 0.57$), through one layer of sheet ($t_{16} = -0.59$, $p = 0.57$), or through one layer of towelling ($t_{16} = -1.22$, $p = 0.25$). Likewise, there was no significant gender difference in the peak vertical force of chest vibration when applied directly through a layer of sheet ($t_{16} = -0.020$, $p = 0.99$) or through a layer of towelling ($t_{16} = -1.11$, $p = 0.29$). However, there was a significant gender difference in the peak vertical force of chest vibration when applied directly on the body ($t_{16} = -2.51$, $p = 0.029$).

There was an expected significant difference in the minimum force between chest shaking and chest vibration (directly over the body: $t_{16} = 4.06$, $p = 0.001$; through a layer of sheet: $t_{16} = 4.26$, $p = 0.001$; through a layer of towelling: $t_{16} = 3.41$, $p = 0.004$). The range was the maximum and minimum force of one waveform. There was a significant difference in the range of vertical force between chest vibration and shaking when applied directly on the skin ($t_{16} = -2.96$, $p = 0.009$),

Table 1 Variation of Frequencies Among the Three Conditions

	Directly over Body	*Through One Layer of Sheet*	*Through One Layer of Towelling*
Number performing vibration	13	15	13
Maximum frequency	10.0 Hz	10.5 Hz	7.5 Hz
Minimum frequency	2.5 Hz	3.0 Hz	2.5 Hz
Mean frequency	5.7 Hz	5.3 Hz	5.0 Hz
SD	2.06	2.07	1.42
Number performing shaking	5	3	5
Maximum frequency	7.0 Hz	7.5 Hz	7.0 Hz
Minimum frequency	3.5 Hz	4.5 Hz	3.0 Hz
Mean frequency	5.3 Hz	5.8 Hz	5.0 Hz
SD	1.65	1.53	1.58

Table 2 Variation of Vertical Forces Among the Three Conditions

Vertical Forces (N)	*Directly over Body*	*Through One Layer of Sheet*	*Through One Layer of Towel*
Mean peak forces	272.78	273.47	271.13
SD	98.32	100.80	97.13
Mean maximum forces of chest vibration (SD)	255.41 (73.26)	257.94 (94.40)	257.30 (74.15)
Mean maximum forces of chest shaking (SD)	317.93 (146.47)	351.12 (114.16)	307.11 (146.16)

Table 3 Vibration Forces by Condition

Condition	*Medial Mean (SD)*	*Lateral Mean (SD)*	*Cephalad Mean (SD)*	*Caudad Mean (SD)*
Condition 1 (directly over body)				
Vibration	83.39 (50.59)	6.32 (12.37)	25.33 (37.50)	43.12 (28.12)
Shaking	33.46 (27.41)	35.36 (19.12)	42.90 (31.98)	35.36 (19.12)
Condition 2 (through one layer of sheet)				
Vibration	66.87 (42.73)	12.79 (16.48)	25.24 (31.74)	36.11 (29.05)
Shaking	36.41 (44.83)	55.98 (19.96)	31.98 (34.72)	36.85 (74.40)
Condition 3 (through one layer of towel)				
Vibration	75.23 (41.91)	14.18 (17.32)	30.02 (32.35)	34.42 (27.87)
Shaking	28.30 (33.41)	43.84 (23.61)	14.56 (10.84)	54.90 (32.28)

through a sheet ($t_{16} = 3.25$, $p = 0.005$), or through a towel ($t_{16} = -2.16$, $p = 0.046$).

The results of medial, lateral, caudad, and cephalad forces are shown in Table 3. There was no significant difference in the medial force ($F_{2,34} = 0.54$ and $p = 0.59$) between chest vibration for the three conditions. A significant difference was noted in the lateral force ($F_{2,34} = 5.39$, $p = 0.008$) for chest vibration for the three conditions (see Table 3). Despite the noticeable difference in applying chest vibration and chest shaking (Table 3), there was no significant difference in caudad ($t_{16} = -0.92$, $p = 0.37$; $t_{16} = -0.33$, $p = 0.75$; and $t_{16} = 1.03$, $p = 0.32$ respectively) and cephalad forces ($t_{16} = -0.55$, $p = 0.59$; $t_{16} = 0.31$, $p = 0.98$; and $t_{16} = 1.34$, $p = 0.20$ respectively) for the three conditions. There was no significant difference between cardiopulmonary physiotherapists and general practice physiotherapists (p-values varied from 0.47 to 0.69 for medial force, from 0.50 to 0.75 for lateral force, from 0.21 to 0.32 for caudad force, and from 0.68 to 0.88 for cephalad force) for the three test conditions.

When the test was repeated with three randomly selected physiotherapists, no significant difference was found in either frequency or force of vibration between the repetition and the performance of these physiotherapists during the study. Analysis of their frequency and force data using an independent t-test produced p-values varying from 0.18 to 0.99.

DISCUSSION

Our study demonstrated considerable variability in the forces and frequencies generated by chest vibration applied by physiotherapists. A few physiotherapists, in fact, performed chest shaking, despite being asked to perform vibration, and were surprised when given the results because they believed they had performed chest vibration. The findings show that measurements made using the plinth are repeatable, as no significant difference was found. This was evident even with chest shaking, as one of the physiotherapists randomly selected to repeat the test performed shaking in all three test conditions during the study as well as during the repeatability study.

Studies have reported the frequency for chest vibration and chest shaking to be 12–16 Hz[6,7] and 2–6 Hz,[6,7,9] respectively. Some claim that vibration is chest shaking (12–16 Hz).[10] Because little work has been done on the effects of fine or coarse oscillations, physiotherapists tend to adapt their techniques to whatever they find most helpful clinically.[1] Some have described chest shaking as a coarser movement, in which the chest wall is rhythmically compressed, and chest vibration as a fine oscillation of the hands directed inward against the chest.[11] The difference between the two techniques appears to be unclear, which may explain why a few physiotherapists perceived their technique of chest shaking as chest vibration.

The mean vibration frequency applied in this study for all three conditions (see Table 1) was consistent with that of another study using a similar experimental set-up but with more experienced physiotherapists.[5] Both that study and ours showed the mean frequencies of vibration lower than those in other studies with recorded frequencies of 10 to 16 Hz.[6,7,9] The seven physiotherapists in our study who performed shaking instead of vibration (in at least one of the three conditions) applied frequencies outside those demonstrated in previous literature of 6.3 Hz[9] and 2 Hz[6,7] (see Table 1). Those studies evaluated vibration, shaking, or both techniques, performed on a black anaesthetic bag[6] or on intubated and ventilated sheep;[9] one study failed to indicate the method of measurement used.[7] It is not clear why these studies demonstrated differences in the frequencies of vibration or shaking. In a series of experiments on dogs receiving high-frequency chest wall compression (a modified double blood-pressure cuff rapidly oscillated by a piston),[4] frequencies of 5–17 Hz showed an enhancement of tracheal and peripheral mucus clearance rates that peaked at 13Hz. However, 3 Hz showed no enhancement of mucus clearance in those experiments.[4] Based on those results, frequencies applied during vibration and shaking in our study might have been effective in mucus clearance.

A previous study showed that physiotherapists with greater clinical experience performed vibration at a lower frequency than physiotherapists with less experience[9] and suggested that the more experienced physiotherapists may have modified the frequency to suit their patients. Our study demonstrated no difference in vibration frequency between cardiopulmonary physiotherapists and general practice physiotherapists. However, female physiotherapists had a significantly higher frequency when chest vibration was applied directly over the body but not when it was applied through one layer of sheet or towelling. The reason for these differences is unclear; they may have been due to an error resulting from the small group sizes of both cardiopulmonary and male physiotherapists.

The maximum mean vertical force of the whole group appears to be high in all three conditions, partly because some physiotherapists performed shaking rather than vibration (see Table 2). As expected, there was a significant difference in the force applied, which was higher for chest shaking than for chest vibration in all three conditions. Three physiotherapists consistently applied shaking in all three conditions. In fact, a female physiotherapist generated the highest vertical force (543.8 N) during shaking. This participant's lowest force applied during shaking was 394 N.

The previous study using the same plinth with more experienced physiotherapists measured a peak force of 137 N during chest vibration.[5] The high forces recorded in our study may have been due to several factors. The main factor was the differences in the BMI of the "patients" in the two studies (33 kg/m^2 in our study vs. 22 kg/m^2 in the previous study). Because of the high BMI of the volunteer in our study, the physiotherapists claimed that a higher force was necessary to transmit the energy waves to the airway. Another possible explanation is that the physiotherapists may have leaned down on the volunteer when applying vibration or shaking, as they were not allowed to lean on the plinth. This component of the methodology is unclear in the previous study that used a similar plinth.[5]

A second factor is that because our data were collected near the end of the day, the high vertical force may have arisen from physiotherapists leaning on the volunteer in order to conserve energy while performing vibration. As a higher force is applied by leaning on a patient, this may have resulted in some physiotherapists' consistently applying shaking in all three conditions. In clinical situations, physiotherapists lean on the bed to get closer to the patient. This source of error was likely minimized by allowing the physiotherapists in our study to adjust the height of the plinth and by positioning the volunteer "patient" as close as possible to the edge of the plinth.

A third factor is that all but three physiotherapists claimed that they needed to place their hands on the volunteer's chest during the inspiration phase to feel the next expiratory phase, as a result of which they may unintentionally have applied some force to the volunteer's chest. This may have contributed to the positive force given to the volunteer by some physiotherapists during the inspiratory phase and to the high forces generated during this study, especially during shaking (see Figure 2).

A high force could potentially cause damage to a frail or elderly patient; a high peak vertical force can also be uncomfortable for the patient, especially toward the end of expiration. Rib fractures are rarely reported from receiving shaking or vibration, and there is no published research that has examined the force required to fracture a human rib. However, there is still a potential danger when using such techniques. "Over pressure" during the inspiratory phase may cause some discomfort to patients with restricted ribcage movement and may hinder expiratory flow.

There was no significant difference in the forces generated during vibration between the cardiopulmonary and general practice physiotherapists in the three tested conditions, or between male and female physiotherapists. Random error may have contributed due to the small group sizes of male and cardiopulmonary physiotherapists.

Although the frequency of vibration in our study was consistent with that found in the study involving more experienced physiotherapists,[5] the force applied was higher than in the previous study. It might have been interesting to evaluate the relative forces applied by physiotherapists in our study if the volunteer's BMI had been similar to that of the patient in the previous study. Because our study was only investigating the technique of vibration as applied by physiotherapists and not the expiratory flow, it is not clear whether applying higher forces to patients with higher BMIs improves expiratory flow. When higher forces are applied, physiotherapists may find it easier to perform coarser, shaking-type movements rather than fine oscillatory movements. This may have led a few physiotherapists in our study to apply shaking instead of vibration, which did not occur in the previous study.[5] In addition, the varying levels of experience of the physiotherapists in our study (ranging from 6 months to 5 years) may have produced the large variations in the standard deviations of the force applied compared to the earlier study. It is very difficult to tell the difference between chest vibration and chest shaking without graphic feedback, as in this study. These physiotherapists may have learned to perform chest vibration similar to the chest shaking technique and thus perceived their technique as vibration. This study demonstrated that there are several inconsistencies in the technique of chest vibration and that each physiotherapist may alter the technique depending on his or her experience and on the BMI of patients. Thus the results are unclear as to the effectiveness of each physiotherapist's technique in improving expiratory flow.

Our data provide a reference for using medial, lateral, caudad, and cephalad forces. These forces, along with the vertical force, produce a combined force that may potentially assist expiratory flow and mobilization of secretions. Further investigation is needed to explore the optimal range, magnitude, and combination of these forces and their effects on expiratory flow in different disease conditions. It is also important to examine patients with different BMIs to evaluate the influence of the force and frequency of vibration on outcome measures such as expiratory flow.

The use of towelling may affect physiotherapists' sensation. The use of thick towelling is not recommended for vibration or shaking, as the production of energy waves may be diminished. Previous studies using human volunteers have not adequately reported the conditions under which vibration was applied.[5–7] However, the study using sheep applied chest vibration directly on the skin.[9] This is hardly ever done in clinical practice, as vibration is usually applied over the patient's clothing.

Our results showed no differences in the forces or frequencies of the techniques when applied across the three conditions. However, the volunteer ''patient'' reported feeling more comfortable when the techniques were applied over a towel. A towel may therefore be recommended when performing vibration or shaking, as the forces and frequencies were not altered by the addition of the towel. However, the question remains whether towelling may affect transmission of waves to the airways. Because our study measured only the external forces applied, it cannot be assumed that the same amount of force would be transmitted to the airways. Perhaps a chest model should be developed to simulate the thoracic cage so that the transmitted waves can be measured.

The main limitation of this study is that vibration was applied on a healthy adult with normal lung function; thus, the results cannot be generalized to a patient population. Frequency and force may differ with variables such as a patient's BMI or altered lung compliance resulting from lung pathology. In addition, vibration was only applied for 10 seconds; it is not clear whether there would be a reduction in force with progression of treatment.

CONCLUSIONS

The study demonstrated a wide range of forces and frequencies when physiotherapists applied chest vibration to a person with normal lung function. No firm conclusions can be drawn, as there are no clear guidelines or other studies that have demonstrated how to alter the technique, depending on patient characteristics, to obtain the optimal frequency or force to assist expiratory flow. This was the first study to examine the use of extra towelling. There was no significant difference in the force and frequency of vibration whether the technique was performed directly over skin, through a sheet, or through one layer of towelling. For patients' comfort, however, at least one layer of towelling is recommended when performing vibration.

KEY MESSAGES

What Is Already Known on the Subject

Although studies on chest vibration have demonstrated beneficial effects of airway clearance, very little research has been conducted to evaluate the technique as performed by physiotherapists.

A single recent study evaluated the chest vibration technique of very experienced cardiopulmonary physiotherapists. However, many physiotherapists working in teaching hospitals have various levels of experience, and their techniques of chest vibration have not yet been examined.

What This Study Adds

Our study demonstrated that there were considerable inconsistencies in the technique of chest vibration when applied by physiotherapists with various levels of experience. The study highlights the need for investigation of the optimal range, magnitude, and combination of these forces and their effects on expiratory flow in different disease conditions and on people with different body mass indexes.

This was the first study to demonstrate no significant difference in the force or frequency of chest vibration when performed directly on the skin, through one layer of sheet, or through a towel.

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